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*THE RELATIONS OF PUBLIC HEALTH SCIENCE TO OTHER SCIENCES.**

"PHYSICAL science is one and indivisible. Although for practical purposes it is convenient to mark it out into the primary regions of physics, chemistry and biology, and to subdivide these into subordinate provinces, yet the method of investigation and the ultimate object of the physical inquirer are everywhere the same."—Huxley.

Physical science is one and indivisible; that, as I understand it, is the key note of this great congress, of which public health science forms one section, and as I am invited to consider, in the brief space of forty-five minutes, the relations of public health science to other sciences, I shall take the liberty of selecting from the whole number of 'other sciences' only a few, the relations of which to public health science seem to me for one reason or another especially important at the present time. I accept the term public health science without hesitation, for any division of human knowledge which has worked out its own laws with strict adherence to the rules of inductive and deductive reasoning, as public health science has done, and which has reached results enabling it to predict with accuracy, as public health science can now predict, is entitled to a place and an honorable place among the physical sciences.

Public health science had its rise and a considerable development in the eighteenth century. Before that time numerous procedures tending to protect or promote the public health had, indeed, at one time or

* Address before the International Congress of Arts and Science, St. Louis Exposition.

another existed, but these were largely empirical and quite as often directed to the convenience of mankind as to their sanitary safety. In this class belong the Mosaic code; the water supply introduced into Jerusalem by Hezekiah; the sanitary engineering of Empedocles; the *Cloaca maxima;* the water supplies of ancient Mycenæ and of Rome, and all the earlier, and too often futile, forms of quarantine. Even the art of inoculation for smallpox was only an ingenious knack introduced from the east, where it had been long used empirically, and although it was a public health measure now of the utmost interest and capable at the time of great practical service, it had until recently no scientific basis, but belonged in nearly the same class as the amulets and charms, the prayers and incantations, of the superstitious.

It was not until the middle of the eighteenth century, namely, in 1767, that Sir George Baker, by the use of the methods of pure inductive reasoning, made the first scientific discovery in public health science in the subdivision of epidemiology, namely, that the epidemic colic of Devonshire, England, was due to an obscure poisoning by lead conveyed through the common cider used for drinking in that district. In 1774 the foundations of state hygiene and sanitation were laid in consequence of the patient investigations and startling revelations of John Howard, by an act of Parliament providing for the sanitation of jails and prisons. The beginnings of marine hygiene and sanitation appear in 1776, when Captain Cook, the navigator, was awarded the Copley medal of the Royal Society for his remarkable success in protecting the lives of his sailors on his second voyage. In 1796 Edward Jenner, working also in a strictly scientific manner, and employing the methods of rigid inductive research, laid securely for all time the foundations of personal hygiene and immunization, by showing how we can produce at will such modifications of the physiological resistance or susceptibility of the human body as to make it immune to smallpox.

The importance of these fundamental and splendid discoveries, not only to the public health of the time, but far more to the development of public health science in all the centuries to come, is incalculable. Reduced to their lowest terms, we have in these eighteenth century discoveries the germs of some of the most important divisions of public health science as it is to-day, namely, (1) *epidemiology,* (2) *sanitation of the environment,* and (3) *immunization of the human mechanism,* this last the most marvelous phenomenon hitherto discovered in personal hygiene.

Time fails me to do more than name some of the principal steps in the advancement of public health science in the nineteenth century. We have, for example, in 1802, the beginnings of factory hygiene and sanitation; in 1829, the first municipal water filter, one acre in area, constructed for the Chelsea Company of London; in 1834, recognition of the important relation of poverty to public health, in the famous report of the Poor Law Commissioners of that year; in 1839, the beginnings of registration and accurate vital statistics; in 1842, an important report on the sanitary condition of the laboring population of England; and in 1843, a similar report on the health of towns; in 1854, for the first time clearly taught, the lesson, even yet not properly taken to heart, that drinking water may be the ready vehicle of a terrible epidemic of cholera. About 1860, striking epidemics of trichinosis first came into public notice, and here, also, belongs the magnificent work of Pasteur, while in 1868, Lister, following in the footsteps of

Pasteur, revealed to the world the basis of true cleanliness in asepsis, and in 1876, bacteriology became firmly established as a science by Koch's studies on anthrax. The decade from 1880 to 1890 may be called the golden age of ætiology, for in these years were discovered the hitherto unknown parasitic microbes of typhoid fever, tuberculosis, malaria, Asiatic cholera, diphtheria and tetanus. The last decade of a century which has well been called 'the wonderful,' witnessed the discovery of antitoxins by Behring and the beginnings of serum therapy. The list is long, and I have not mentioned nearly all of the discoveries of capital importance, but because of these and their fruits, I am in the habit of saying to my students that with the single exception of the changes effected by the acceptance of the theory of organic evolution, there has been no modification of human opinion within the nineteenth century more wonderful, or more profoundly affecting the general conduct of human life, than that in our attitude toward the nature, the causation and the prevention of disease—that is to say, toward public health science.

No mere outline like this of the history of public health science can possibly serve to show how, like other applied sciences, this one has not grown as a branch grows from a tree, namely, from a large stem or stock of knowledge, tapering out into thin air, and with its latest growth its least and weakest. That common simile in which the various divisions of science are represented as branches of the tree of knowledge, is a grotesque survival of a time when neither trees nor science were understood. No simile is perfect or even approximately correct, but one better than the tree and its branches for the origin and relationships of any inductive science is that of a river, rising from various and often obscure sources, growing in size and importance as it proceeds both from the springs within its own bed and by the entrance and contributions of tributary streams, and finally pouring its substance into the mighty ocean of accumulated human knowledge.

Up to the time of the establishment of the registration of vital statistics in England, in 1839, the stream of public health science, although full of promise, was only a slender thread, but when the results of registration were fully enlisted in its service it visibly widened and deepened. Epidemiology, as has been said, had the honor of giving birth to the science in 1767, and it added to its offspring a rich endowment when, in 1854, Dr. John Snow proved that the water of the Broad Street well in London had caused an epidemic, in which more than six hundred persons died of Asiatic cholera. The stream of public health science was still further enlarged and quickened by the revelation in and after the sixties of the simple causes of numerous epidemics of trichinosis and of typhoid fever, the latter sometimes through milk. There was an extraordinary popular awakening in England to the importance of sanitation and public health measures in the middle of the nineteenth century, but we look for some time in vain for any marked inosculation between public health science and other sciences, such as physics, chemistry, microscopy, bacteriology, climatology, engineering or education. We have, to be sure, minor contributions from the microscopists, such, for example, as that from Dr. Hassall, who, in 1850, made a careful microscopical examination of the water supply of London and showed the presence in the public drinking water of muscle fibers, intestinal parasites and other materials, plainly derived from sewage; but it was

not until Pettenkofer and his disciples, in Germany, and Angus Smith and others, in England, began their splendid chemical investigation that the tributary stream of *sanitary chemistry* enlarged materially that of public health science. In saying this I do not forget that my late friend and colleague, William Ripley Nichols, whose solid contributions to sanitary chemistry were among the first in America, and will always remain among the best anywhere, long ago pointed out that, as early as 1789,

> Fourcroy studied the nature of 'litharged' wine, Berthollet (1801) the methods of preserving water for long voyages, Chevreul (1846) various chemical reactions which explain the hygiene of populous cities, and (1856, 1862, 1870) methods of preparing and preserving food; Graham and Hofmann reported upon the use of acetate of lead in sugar refining (1850), upon the London water supply (1851), and upon the adulteration of pale ales with strychnine (1882); Dumas was interested in many sanitary matters and made, among others, reports on the mineral waters of France (1851), on the water supply of Paris (1859), on the treatment of sewage (1867), and on the preservation of food (1870–72); Wurtz was for a number of years president of the *Comité consultatif d'hygiène* and a year before his death was president of the *Société de médecine publique*. His investigations and reports on sanitary subjects are numerous—on the disposal of the waste from distilleries and sugar-refineries, on the colors employed on German toys and in articles of food, on the adulteration of wines, etc.
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> Other names will occur to us—such as those of Sir Henry Roscoe, Sir Frederick Abel and Dr. Williamson, who served on the Noxious Vapours Commission of 1876; of Frankland, who gave years of service to the Rivers Pollution Commission of 1868 and in connection therewith devised an elaborate system of water analysis; we think also of Schutzenberger devising a method for the determination of oxygen dissolved in water (not, to be sure, simply for sanitary purposes), Mallet studying the various methods of water analysis, Remsen studying the organic matter in the air, and Leeds the practical effect of charging with oxygen (or rather with air) water used for purposes of domestic supply.*
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> * Wm. Ripley Nichols, address before American Association for the Advancement of Science, *Proceedings American Association for the Advancement of Science*, Vol. XXXIV., 1885.

I dwell intentionally upon the service of sanitary chemistry to public health science previous to the rise of bacteriology, because I believe that, dazzled as we have been and still are by the blazing achievements of bacteriology, beginning, let us say, with the discovery of the microbe of tuberculosis by Koch in 1882, students of public health science have been too much inclined to underrate the past services and present relative importance of sanitary chemistry. I know of few more important contributions to public health science, even since 1882, than the chemical work of the State Board of Health of Massachusetts under the able direction of my friend, Professor, afterwards President, Drown (the successor of Nichols) and his associates and successors; or that of another friend, the late Professor Palmer, of the University of Illinois, whose chemical studies of the rivers of Illinois will long remain a monument to a life full of promise and too soon cut short, or that of still another friend, Professor Kinnicutt, who fortunately is still engaged in fruitful work.

I have perhaps said enough, though it would be difficult to say too much, of the magnificent contributions to public health science of Pettenkofer and his disciples in sanitary chemistry; but the work of these investigators in *sanitary physics* and especially the physics of the soil, of the atmosphere, of the walls of buildings, and of heating and ventilation, in their relations to the public health are quite as important, and perhaps to-day even more neglected. In view of the increased facilities for transportation and the growing habit of traveling, together with the tendency to outdoor life, which seem to be characteristic to-day of all civilized nations, the next twenty-five years will probably see a re-

turn to the patient and exact studies of *the environment,* such as the chemists and physicists began, and have in some measure continued, since the middle of the nineteenth century. These studies will be directed largely to further knowledge and control of the environment, but they will not end there, for *personal hygiene,* owing to recent advances in physiology, is to-day one of the most inviting fields for work and education, and I hardly need to point out to a company of experts that the proper care and right use of the individual human mechanism reacts favorably and fundamentally upon the public health no less truly or effectively than an improved condition of the environment or of the public health tends to promote the welfare and long life of the individual.

The sphere of hygiene may be divided, as it often is, into the two hemispheres, public hygiene and personal hygiene, or it may be cut into one portion dealing chiefly with the human mechanism and its operation (*personal hygiene*), and another portion dealing chiefly with the environment of that mechanism (*sanitation*). The time has gone by when any one person can safely undertake to deal with the whole sphere of hygiene. The physiologist and the physician must in the future leave to the architect and the sanitary engineer such subjects as housing, heating and ventilation, water supply and sewerage, precisely as the sanitary engineer has never presumed to deal with foods and feeding, vaccines and antitoxins, exercise, sleep and rest. The former subjects deal chiefly with the control of the environment, the latter subjects chiefly with the control of the individual, and sanitation and hygiene must henceforward be regarded as separate hemispheres of the science of health.

The *science of architecture,* if under this head we include the principles of building construction, and the heating and ventilation of buildings, has done and is doing much of interest and importance to the student of public health science. For my own part, I am continually more and more impressed with the fact that the air supply, especially for the modern civilized and too often sedentary form of mankind, is in the long run quite as important as the water supply, the milk supply or any other supply. Surely, we can not be too careful of the purity of a substance which we take into our bodies oftener, and in larger volume, than any other, and which has come, rightly no doubt, and as the result of long and painful experience, to be known as the very breath of life. I am well aware that human beings may survive and seemingly thrive, even for long periods, in bad air, but I am certain that for the best work, the highest efficiency, the greatest happiness and the largest life, as well as for perfect health, the very best atmosphere is none too good. Hence I believe that the permeability of the walls of houses and other buildings, and the heating and ventilation of dwellings, school houses, churches, halls and other public places, require, and in the near future will receive, a much larger share of our attention than they have to-day.

In an age characterized by urban life and possessing sky-scrapers, tenement houses and other huge bee-hives, in which human beings aggregating vast numbers spend a large part of their lives, buildings require for their proper construction, lighting, heating, air supply, water supply, gas supply and drainage, the scientific services not only of architects, but of engineers, and such public buildings form one small section of the aid which modern *engineering science* is now everywhere rendering to public health science. The present has rightly been called an 'age of engineering,'

and to no other science, excepting only medicine itself, is public health science to-day more indebted than to engineering science. I have referred above to the construction of the first municipal filter attached to a public water supply as that of the Chelsea Company of London, constructed in 1829. How different is it to-day! Not only nearly the whole of London, but also Berlin and Hamburg, and a thousand lesser cities all over the civilized world, are now protected more or less perfectly from epidemics of typhoid fever, Asiatic cholera and other water-borne diseases by vast municipal filters, ingenious and scientific in design and costly in construction, the work of skillful and faithful engineers, and monuments, more precious, if less enduring, than brass, to the contributions of engineering science to public health science. Innumerable storage reservoirs and vast distribution systems for supplies of pure water also bear witness to the enormous debt which public health science owes to engineering science, as do proper street construction and, still more, those splendid systems of sewerage with which so many modern cities are equipped, and which not only serve to remove quickly the dangerous liquid waste of human and animal life, but also keep low and wholesome the level of the ground water, reducing dampness and promoting dryness of the environment, and thereby strengthening that physiological resistance by means of which the human mechanism fights against the attacks of infectious disease. Nor do the services of engineering science end here, for the fluid content of the sewers must always be safely disposed of, and sewage purification is to-day a problem of engineering science no less important or difficult than that of water purification. These same processes of the purification of water and sewage are matters of so much moment in public health science that in almost every country experiment stations are now maintained at public and private expense for the purpose of working out the most practical and most scientific methods of purification.

In no respect have the services of engineering science to public health science been more conspicuous than in the application and the further study of the principles involved in the processes of water purification. It has lately been shown, for example, that the introduction of pure water supplies has in many cases so conspicuously lowered the general death rate as to make it impossible to escape the conclusions (1) that the germs of a greater number of infectious diseases than was formerly supposed are capable of prolonged life in, and ready conveyance by, public water supplies, and (2), as a promising possibility, that as the result of the greater purity of the water supply the physiological resistance of the consumers of pure water supplies is enhanced, in some manner as yet unknown; the net result being that the general death rate is lowered to such an extent as to lead to a rapid increase of population in communities previously stationary or multiplying far less rapidly. In the case of the city of Lawrence, Mass., for example, I have recently had the privilege of examining the results of studies by the distinguished hydraulic and sanitary engineer, Mr. Hiram F. Mills, which show that since the introduction of a municipal filter, which purifies the water of the Merrimac River supplying water to the citizens of Lawrence, while the population has increased nearly seventy per cent., the total number of deaths remains about the same as it was ten years ago. Mr. Mills concludes from the results of his studies—and I see no escape from his conclusions—that the introduction of the municipal filter has

not only saved the lives of thousands of citizens, but has also caused the population to increase to a point much beyond any which it would have reached had the city continued to use, unpurified, the sewage-polluted water of the Merrimac River. A demonstration of this sort shows how easily the diminishing increase of population under a lower birth rate may sometimes be counteracted without resort to that fish-like spawning which seems to be the only remedy of those who are terrified by 'race suicide,' so called. Moreover, it is hardly necessary to point out that such a diminishing death rate means a far more rapidly diminishing morbidity rate—in other words, it means a heightened working efficiency of the population as a whole, and it must not be forgotten that for most of the results obtained in the scientific purification of water supplies we are indebted to the science of engineering.

On the other hand, we must observe that engineering science, so far as water purification is concerned, is as yet only in its infancy and by no means thus far altogether satisfactory. In the United States, for example, in the last two or three years a number of epidemics of typhoid fever have resulted from the *defective operation or construction* of municipal filters, and while much has been done, it is clear that much still remains to do. In this connection it should be said that public health science in the United States suffers constantly and severely from an unsatisfactory condition of the science and art of administration or government in many American cities. Public health works are too often neglected, delayed, mismanaged or built at extravagant cost, to the sanitary and economic damage of the people as a whole, and the tendency is far too common to place the care and operation of costly devices or systems in incompetent hands.

I can not here dwell, as long as I should like to do, upon the mutual relations of public health science and the sciences of legislation and administration. Speaking of my own country alone, I must confess that we are still very deficient in the applications of these sciences. We have not even a national board of health, although we have, fortunately, in the Public Health and Marine Hospital Service a strong substitute for one. The peculiarities of our democratic and republican government have hitherto made it impossible for the people of the United States to secure either from federal authorities or from more local sources that measure of paternal sanitary and hygienic protection which they ought to have, and it is the duty of every American worker in this field to bend his energies toward a better organization of the public health service in every direction, municipal and state as well as national. The appointment in 1886 of a distinguished hydraulic engineer to membership on the State Board of Health in Massachusetts marked an epoch, so far as America is concerned, in both sanitary legislation and administration. This appointment was a formal recognition on the part of the public of the necessity of a larger proportion of engineering science in matters relating to the public health, and the results have justified the new procedure. It is now, fortunately becoming less rare in America to secure the services of engineers upon such boards and there can be no question that participation of the expert laity with medical men is likely to be extended, probably far beyond our present ideas.

In a notable discourse before the International Medical Congress at the Centennial Exposition held at Philadelphia in 1876, Dr. Henry P. Bowditch, of Boston, one of the pioneers of hygiene and sanitation in America, divided the century then

closing, as to its relation to public health science, into three periods, the first, from 1776 to 1832, a period of reliance upon authority and upon drugs; the second, from 1832 to 1869, a period of true scientific observation; the third, from 1869 onwards, an epoch in which the medical profession is aided by the laity and state hygiene is inaugurated. Dr. Bowditch has much to say of the desirability of a wider cooperation of the laity in state hygiene and remarks: 'In all that tends to the promotion of state hygiene hereafter the laity will naturally and cordially cooperate with the [medical] profession.' The history of public health science shows Dr. Bowditch's prediction to have been well grounded. The names of John Howard and Captain Cook in the eighteenth century, and of Edwin Chadwick, John Simon and Louis Pasteur (not to mention a host of lesser workers) in the nineteenth century, show conclusively that public health science has been, even from the start, by no means confined to medical men. We may go further and say that even when forwarded by medical men these have seldom been busy practitioners. Sir George Baker and Jenner were, it is true, of this class, but not Pettenkofer or Koch or Ross or Billings or Reed.*

Reflections of this sort naturally lead to a consideration of the reciprocal relations of public health science and the science of education. I do not need to dwell upon the beneficial effects of public health science upon the hygiene and sanitation of school children or school houses. These benefits have long been emphasized by sanitarians and sanitary reformers, and are sufficiently obvious. The reverse of the picture, however, is by no means so well understood. Unless one is familiar with the facts, it is difficult to conceive how little impression the splendid progress which the last fifty years have witnessed in public health science has as yet made upon the curriculum of education. From top to bottom and from bottom to top the schools, whether primary, grammar, high, normal, technical, medical or any other class, are recreant, inasmuch as they neglect almost wholly any adequate training of their pupils in the principles of public health science, which are confessedly of such profound importance to mankind. There is, to be sure, just now a popular wave of enthusiasm touching the extermination of tuberculosis, but in the United States, at any rate, both schools and universities are singularly negligent of their most elementary duties in this direction. Yet if what I have said before is true, if the laity are to participate from this time forward with medical men in sanitary and hygienic legislation and administration, if engineers and medical men in particular are to serve upon boards of health or in other executive positions connected with public works, then, surely, it is the duty of the science of education to lend its powerful aid and not to fail to save the lives and health of the people as these can be saved to-day, but always to promote that public health and that large measure of consequent happiness which can probably be more easily and quickly accomplished in this way than in any other.

As to the function of medical education and engineering education in respect to the dissemination of public health science, I shall say only a word. In spite of the reiteration by medical men of their belief in the importance of hygiene and preventive medicine as a part of the equipment of the medical profession, it is a significant fact that in America even the

* "During the course of an epidemic physicians are too busy to make observations which require much time or care, or to make more than brief notes."—J. S. Billings.

best medical schools devote very little time to any adequate instruction in these subjects. It may be that this is wise and that the pressing necessities of practical medicine forbid any extended instruction in public health science. I am willing to believe, if I must, that this may be the case; but if it is, then the community must look for the most part elsewhere than to medical men for adequate investigation, legislation and administration of public health science. Medical men, must, of course, always participate in the work, in connection, particularly, with the control of epidemics and in those forms of preventive medicine which have to do with vaccines, serums and other means of modifying the vital resistance of the human body. But as regards the care and control of the environment, medical knowledge is not indispensable, and the entrance of the engineer and the sanitary expert upon the field, as foretold by Dr. Bowditch nearly twenty years ago, is today a conspicuous, and probably a wholesome, fact. As to the attitude of engineering education toward public health science there can be no question. If what I have said before is true, then engineers are bound in the future to take constantly a larger and more important part in public health work, and must be informed, and if possible trained, accordingly. Moreover, as regards both medicine and engineering, the problem is by no means insoluble, for a very short course of instruction rightly given would easily inculcate the necessary fundamental principles, while electives or post-graduate work might enable those few whose tastes led them in this direction to investigate and specialize and more thoroughly prepare themselves for public service.

I can not treat, nor do I need to treat, as thoroughly as I would be glad to do, the mutual relations existing between medical science, especially the science of medical bacteriology, and public health science. These are already sufficiently obvious and well known. From time immemorial medical men have served, often devotedly and sometimes heroically, in the cause of public health science. I take it, however, that since we have in this congress and in our own department a section of preventive medicine, I may pass over without comment this part of my subject.

As regards sanitary bacteriology, however, the relations existing between this and public health science are so fundamental, so extensive and so important, not only on the medical, but also on the engineering side, that although we have also in this congress under the department of biology, as is entirely proper, a section of bacteriology, I may linger at this point for one moment. The bacteria and other microscopic forms of plant and animal life, all of which are conveniently included under the term microbes, have so lately begun to be understood and appreciated that we must still emphasize their extreme importance. The discoveries of the botanists and zoologists and revelations of the microscopists in this domain are comparable, in their importance to public health science, with nothing less than the revelations of the telescope to astronomy. Astronomy had, indeed, existed long before the invention of the telescope, and public health science, as we have shown above, had its beginnings nearly a century before any considerable progress had been made in micro-biology. But it is not too much to say that the developments in microbiology since Pasteur began his work have not only revolutionized our ideas of the nature of the infectious diseases, but have also placed in our hands the key of their complete control.

Concerning the relations of *physiology*

to public health science, I must not fail to speak. Here is a field absolutely ripe for the harvest, but one in which the harvesters are as yet very few. I have lately had occasion to examine somewhat carefully the present condition of our knowledge of personal hygiene—which is nothing more (and should be nothing less) than the applications of physiologial science to the conduct of human life—with the result that I have been greatly impressed with its vast possibilities and promise. Man is a gregarious animal, and mankind is to-day crowding into cities as perhaps never before. Moreover, the industrial and commercial age in which we live is characterized to an extraordinary degree by the sedentary life. Yet the sedentary life is almost unavoidably an abnormal life, or at least it is a life very different from that lived by most of our ancestors. In the sedentary life the maintenance of a high degree of physiological resistance apparently becomes difficult, and if the vital resistance of the community in general is lowered then the public health is directly and unfavorably affected, so that considerations of personal hygiene have a direct bearing upon the science of public health.

There are, to be sure, interesting and suggestive symptoms of a wholesome reaction, in America, at any rate, against the evils of the sedentary life. Parks and open spaces are being liberally provided; public and private gymnasiums are rapidly coming into being; public playgrounds are thrown open in many of our cities, free of expense to the laboring, but, nevertheless, often sedentary, population; vacations are more than ever the fashion; sports and games are everywhere receiving increasing attention; while public baths and other devices for the promotion of personal hygiene are more and more coming into being. All this is as it should be, but all is as yet only a beginning. Here, again, the science of education is sadly at fault and in the direction of educational reform as regards personal hygiene lies immense opportunity for a contribution to public health science.

The science of *statistics*, which has done great service in public health science in the past, is likely to do much more in the future. Without accurate statistics of population, mortality and the causes of sickness and death, the science of epidemiology is impotent, and the efficiency or inefficiency of public health measures can not be determined. And yet in ignorant hands statistics may be worse than useless. It is a matter for congratulation to Americans that we now have in Washington a census bureau permanently established and under expert supervision, but until the various states and cities of the United States follow this excellent example of their Federal Government, one of the most important aids to public health science will continue to be wanting, as is unfortunately too often the case to-day not only in America, but in many other parts of the civilized world.

William T. Sedgwick.
Massachusetts Institute of Technology.

Scientific Books.

Manual of the Trees of North America (Exclusive of Mexico). By Charles Sprague Sargent, director of the Arnold Arboretum of Harvard University, author of the Silva of North America; with six hundred and forty-four illustrations from drawings by Charles Edward Faxon. Boston and New York, Houghton Mifflin and Company; Cambridge, The Riverside Press. 1905. Pp. 24 + 826, octavo.

A few years ago Professor Sargent brought to a successful close his monumental work, 'The Silva of North America,' in fourteen massive quarto volumes, and including descriptions and figures of 585 species of trees.

While this must for centuries be the standard work on our native trees, its bulk and cost preclude its use elsewhere than in the herbarium, museum or library, and it was imperative that the same author should prepare a handy field (or rather, forest) manual which should give to a much larger number of people the opportunity of studying our forest trees. This has now been done in an admirable manner in the Manual which made its appearance some time in March of the present year.

The book opens with a synopsis of the sixty-one families of plants included, the sequence being that of Engler and Prantl's 'Die Natürlichen Pflanzenfamilien,' and this is followed by an analytical key to the families, based on the characters of the leaves. Then follows the descriptive manual proper, in which after a clear and pretty full characterization of each family there is given a conspectus or analytical key to the North American genera. The characters of each genus are set forth much more fully than they are in the usual botanical manuals, and a paragraph is usually appended giving geographical, numerical and economic data. A convenient key enables the student to readily find the particular species in which he is interested.

The specific descriptions leave nothing to be desired, usually including full descriptions of the leaves, flowers, fruits, seeds, the tree as a whole, its winter buds, bark and wood, and are followed by concise accounts of their natural geographical distribution, and the extent of their cultivation for ornamental and other purposes. With each species is a figure of the characteristic features of the species, usually the foliage, flowers and fruit. By means of these figures alone one can identify nearly every species.

The book is thus thoroughly satisfactory, and must at once become a standard among systematic manuals. It will appeal to the general botanist as a distinct and notable contribution to the literature of systematic botany, and at the same time it will be recognized by students of forestry as an indispensable handbook. For the latter, in this day of forestry schools and forestry courses of study in the colleges and universities, it is indeed fortunate that this manual has made its appearance. Without it North American dendrology was a most difficult subject for both professor and student, on account of the scattered and uncoordinated descriptions in the botanical manuals—the 'Silva' being quite too expensive a work for every-day use by students. This difficulty is now wholly removed by the publication of the manual.

Looking over the families which include North American trees, one finds that the conifers number 90 species and varieties; the palms, 10; *Liliaceae*, 9; the *Juglandaceae*, 15; *Salicaceae*, 32; *Fagaceae*, 52; *Rosaceae*, 169 (of which 132 are species of *Crataegus*); *Leguminosae*, 34; *Aceraceae*, 17; *Cornaceae*, 8; *Ericaceae*, 9; *Oleaceae*, 19. The generic and specific nomenclature is modern, so that one finds *Tumion* (instead of *Torreya*), *Hicoria* (instead of *Carya*), *Toxylon* (instead of *Maclura*), *Malus* (instead of *Pyrus*), *Sassafras sassafras* (instead of *Sassafras officinale*), and *Catalpa catalpa* (instead of *Catalpa bignonioides*). No attempt is made to cite synonyms, the author evidently assuming that the student might well trust him in the selection of the oldest available name. The author has added a handy glossary of technical terms, and the volume closes with a very full index in which English and Latin names are arranged in a single alphabetical series, thus avoiding the nuisance of two indexes, one for the common and another for the scientific names.

This book suggests to one that Professor Sargent is the man to give us a similar book devoted to the exotic trees (and probably shrubs also) of which so many are now given in this country.

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

SCIENTIFIC JOURNALS AND ARTICLES.

The Journal of Comparative Neurology and Psychology for May contains an article of 100 pages, entitled 'The Morphology of the Vertebrate Head from the Viewpoint of the Functional Divisions of the Nervous System,' by J. B. Johnston, of West Virginia University. The 'head problems' have recently re-

ceived renewed study from the standpoints of comparative anatomy and comparative embryology by some of our ablest morphologists, but none of these researches appears to give adequate attention to the recent phases of the doctrines of nerve components and the functional subdivision of the nervous system. Professor Johnston reviews this literature exhaustively from the new point of view and in the light of his own researches (partly not before published), discussing the problems of head morphology and segmentation with illustrative diagrams and tabular summaries. The phylogeny of the organs of special sense is discussed fully with reference to their primitive segmentation and their derivation from more primitive types of sensory mechanisms.

Bird-Lore for May–June contains the following leading articles: 'The Motmots of our Mexican Camp,' C. William Beebe; 'Some Early American Ornithologists, II., William Bartram,' Witmer Stone; 'The American Bittern at Home,' E. G. Tabor; tenth paper on 'The Migration of Warblers,' W. W. Cooke; Notes and Book News and Reviews. The section devoted to 'The Audubon Societies' contains much encouraging information in regard to bird protection, but shows that continued effort is still necessary, particularly in the case of game birds. The final paper is a 'leaflet' devoted to the Barn Owl and showing his good qualities as a mouser.

The Popular Science Monthly for June contains papers by the following contributors:

William A. Locy: 'Von Baer and the Rise of Embryology.'

Edward S. Holden: 'Galileo.'

Arthur H. Daniels: 'The Teaching of Logic.'

Charles A. White: 'The Mutations of Lycopersicum.'

Henry S. Williams: 'What is Research?'

W. J. Beal: 'Plants that Hide from Animals.'

SOCIETIES AND ACADEMIES.

THE GEOLOGICAL SOCIETY OF WASHINGTON.

The 168th meeting of the Geological Society of Washington was held on April 26 at the Cosmos Club.

As informal communications, Mr. L. C. Graton exhibited photographs of Taughannock Falls, New York, and Dr. F. E. Wright explained a new method of determining the optical character of minerals. The regular program included the following papers:

The Ore Deposits of the Ouray Quadrangle, Colo.: Dr. J. D. Irving.

The ore-deposits are located in a small area of about three and one half miles square in the precipitous country in the near vicinity of Ouray, Colo.

The rocks of the region comprise a series of sedimentaries ranging in age from Algonkian to Cretaceous, with included porphyries, while the higher hills are capped by thick beds of volcanic tuff.

The ores are classified as silver-bearing fissure veins, gold-bearing fissure veins, replacement deposits in quartzite, replacement deposits in limestone.

The silver-bearing fissure veins penetrate the sedimentaries and pass occasionally upward into the volcanic tuff. They carry galena, tetrahedrite and some other sulphide in a gangue of barite and quartz. Replacements of limestone occur where beds of this rock are penetrated by the fissures. The silver values are present in the tetrahedrite.

The gold-bearing fissure veins are associated with intrusive dikes of monzonite-porphyry, and contain chiefly auriferous pyrite with some chalcopyrite in a gangue of quartz and crushed country rock.

The replacement deposits in quartzite are flat shoots of gold-bearing pyrite with a little galena and other sulphides which have been deposited in quartzite. It is thought that they owe their origin to alkaline waters that have ascended to the quartzite through minute fissures. The quartzite is fully replaced only in the neighborhood of the fissures and is surrounded by empty solution cavities in the quartzite resembling those usually encountered in the limestone beds. The ores range from $30 to $600 in value.

The replacement deposits in limestone are of three kinds. One is in the limestone beds along the courses of the normal fissure veins

where they form flat, lateral enrichments of such veins.

2. Large flat bodies of silica and barite with silver-bearing ores associated with minute supplying fissures.

3. Deposits of gold-bearing ore composed of an intimate mixture of pyrite and magnetite with actinolite, quartz, epidote and other minerals of supposed contact origin. This class of deposit carries low values in gold and is thought to have been deposited by replacement together with the associated minerals by circulating waters subsequent to the porphyry intrusions.

The geological age of all of these ores is Post Eocene.

Structure of the Great Plains and the Mountains on their Western Margin: N. H. DARTON.

With this communication there was presented an illustration showing the configuration of the Dakota sandstone under the Great Plains and on the flanks of the uplifts westward. This widespread formation has been extensively explored in its underground distribution, by numerous deep wells, and its outcrop area has been mapped so that the structure of much of the region which it underlies is ascertained. This structure was shown by 100- and 500-foot contour lines and it exhibits many notable features. In general, under the Great Plains, the formations have but little dip and wide areas are monoclinal. The uplifts along the mountain border and in southeastern Colorado are marked features and it has been discovered that there is a low anticline extending across north-central Kansas and western Nebraska nearly to the Black Hills. In the bottom of the basins about Denver and northeast and northwest of the Black Hills the Dakota sandstone lies below sea level. In eastern South Dakota it abuts against the Sioux quartzite and is overlapped by Benton formation.

Two diagrams were exhibited, illustrating the configuration of the Black Hills and Bighorn Mountain uplifts by contour lines drawn at the surface of Minnekahta limestone in the former and Bighorn limestone in the latter. In the central area of these uplifts, where the sedimentary beds have been removed by erosion, hypothetical contours are given. Both these uplifts are of the 'Uintah type,' steep-sided and flat-topped and evidently due to direct upward pressure and not to crustal contraction. Profound but local faults along the east side of the Bighorn Mountains are notable features, due mainly to local uplift in Laramie time.

Fault Phenomena Near Glen Echo, Md.: G. K. GILBERT.

The locality is a disused quarry on the north bank of the Chesapeake and Ohio Canal, about one fourth mile east of Glen Echo. The rock is gneiss. It is traversed by numerous systems of joints, as many as twenty having been noted. These are inclined in various directions and at various angles. The joints of each system are approximately parallel, with interspaces ranging from a few feet to at least several yards. The joint surfaces most broadly exposed are not true planes, but show curvature. Many of the joints are evidently surfaces of slipping, or fault planes, the observed dislocations ranging from a fraction of an inch to two or three feet.

The joint systems may be classed in two series, of which one is younger than the other. Many of the joint faces of the younger series are slickensided, and some of the joints contain veins of quartz. The older joints show no slickensides and carry no veins, although there is independent evidence that they are planes of faulting. Their surfaces have a faint but persistent undulation or mammillation.

Where two fault planes of the older systems intersect, each is dislocated by the movement along the other, but the dislocated parts are connected by a fluted surface suggestive of an ogee molding. This phenomenon is supposed to indicate simultaneous (or alternating) movement on the intersecting planes while the rock was within (or at the border of) the zone of flowage. Similar movement in the zone of fracture produces splintering or crushing at the intersections.

The joint systems are interpreted as the re-

sults of successive strains distributed through a long period, the older having occurred when the rock lay below the zone of fracture.

Geo. Otis Smith,
Secretary.

THE CHEMICAL SOCIETY OF WASHINGTON.

The 159th regular meeting was held Thursday evening, May 11, 1905, in the assembly hall of the Cosmos Club.

The first paper, entitled 'Chemical Glassware,' was presented by Mr. Percy H. Walker. Analyses and tests of durability and solubility of a number of beakers and flasks were given, and samples of the various glasses shown. The most suitable for chemical use were zinc boro silicates, and may be distinguished by permanent trade marks. Much of the lime alkali silicate glass sold in this country is of very poor quality.

The second paper, entitled 'A Colorimeter for General Use,' was presented by Dr. Oswald Schreiner. The speaker called attention to the increasing use of colorimetric methods for purely analytical and commercial purposes for both organic and inorganic compounds, and also for carrying on scientific studies in physical, physiological, sanitary and agricultural chemistry. A colorimeter of improved form was then exhibited and described. The parts coming in contact with the liquids are entirely of glass, mounted in a camera of wood. This instrument has the great advantage of speed and accuracy combined with great versatility of application to colorimetric solutions, together with simplicity in construction.

The third paper, entitled 'The Occurrence of Extractives in Apple Skin,' was presented by Mr. H. C. Gore. The quantities were given in which apple wax and apple vitin occur in the epidermis of the apple, both on ripe apples and on apples examined at intervals during growth. The method of analysis of apple skins for apple wax and apple vitin, stated briefly, consisted of extracting the marc of the skin with petroleum ether, followed by chloroform, the petroleum ether extracting the wax and the chloroform removing the vitin. The extracted wax was green or yellow colored, and melted at 59°–60°. The crude vitin was a white powder tinged with green or yellow and melted at 240°–250° C. The two varieties of summer apples examined were poorer in these extractives than the five varieties of winter apples. The extractives were found to increase steadily during the growing season. In case of ripe winter apples the wax amounts to about 30 mgms. per apple, the vitin to about 60 mgms. The probable importance of such studies in connection with the disease resistance of fruits was discussed.

Mr. F. P. Dewey exhibited a specimen of sodium ferrocyanide.

A. Seidell,
Secretary.

THE NEW YORK ACADEMY OF SCIENCES.
SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

The regular monthly meeting of the section was on April 17 at the American Museum of Natural History, with Dr. W. S. Day in the chair in the absence of Dr. Ernest von Nardroff. The program consisted of the following papers:

Purposes and Plans of the Solar Eclipse Expedition of August, 1905: S. A. Mitchell.

Dr. Mitchell gave an outline of the plans of the various expeditions to be made to observe the total solar eclipse which takes place next August and which will be visible in Labrador and Spain. He also spoke of the different problems that the members of the expeditions will endeavor to solve. The U. S. Naval Observatory expedition which Dr. Mitchell will accompany will go to Spain on the U. S. cruiser *Minneapolis* early in the summer. The paper was illustrated by lantern slides.

Variation of the Duration of Afterglow with Change of Electrical Intensity and Frequency of Oscillation of the Electrodeless Discharge: C. C. Trowbridge.

A long-continued study of the duration of afterglow has shown that smooth curves can be readily obtained showing the variation of the duration of the afterglow with change of pressure of the gas. It has been found that the maximum of duration of these curves, when

the electrical intensity is small, is at the same pressure approximately as the minimum sparking potential of the electrodeless discharge, or the point at which the discharge is most easily started. Also, when the frequency of the discharge is altered by a change of capacity, the position of the maximum point of the duration curve is altered to correspond to the displacement of minimum sparking potential of the discharge.

Lengthening the spark gap and thereby increasing the electrical intensity inside of the vessel in which the discharge takes place changes the form of the duration curve, and when the electrical intensity is thus increased above a certain amount the curve obtained is completely altered in form. When the afterglow in the rarefied air is allowed to diffuse into a vessel cooled to liquid air temperature, the duration curve is displaced some distance towards the higher pressure and is also changed in form, other conditions being the same; otherwise, the duration of the afterglow, which in the experiments was approximately thirty seconds, was found to be little different than when the air is at normal temperature. That a long-enduring glow can be obtained at the low temperature of liquid air and a pressure approximately one tenth of one millimeter is obviously important in its bearing on problems of astrophysics.

The Figure of the Sun, an Explanation of the Motions of Mercury: C. L. POOR.

This paper, which is being published by the Academy, was read by title.

The meeting then adjourned.

C. C. TROWBRIDGE,
Secretary.

THE AMERICAN CHEMICAL SOCIETY.
NEW YORK SECTION.

THE eighth regular meeting of the New York Section of the American Chemical Society was held at the Chemists' Club, 108 West 55th St., Friday, May 5, at 8:15 P.M. The chairman, Dr. Wm. J. Schieffelin, presided.

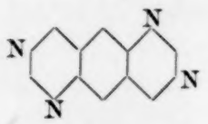
The program of the evening was as follows:

An Improved Form of Viscosimeter for the Testing of Oils: DANIEL D. JACKSON.

The earlier forms of instruments for the determination of the viscosity of oils consisted of bottles or bulbs which delivered a certain quantity of oil through an orifice of definite size. The necessity for jacketing such instruments soon became evident, and various methods were employed for this purpose. In only a few cases, however, has any attempt been made to protect the orifice so that a uniform temperature at this point would be assured, and in the cases where the orifice has been protected the oil under examination has been allowed to flow into a vessel which was outside the instrument. This causes a fall in temperature from the beginning to the end of the operation which is very considerable. A form of apparatus designed by the author for the testing of the viscosity of oil at 70° F. (21.1° C.) and 212° F. (100° C.) is so arranged that both the orifice and the oils under examination are kept at an exactly uniform temperature throughout the entire operation, and two very considerable errors in the results are thereby eliminated.

Condensation of Succinylosuccinic Ester with Guanidine: A. W. DOX and M. T. BOGERT.

Various attempts were made by the writers to produce a naphttetrazine of the following structure:

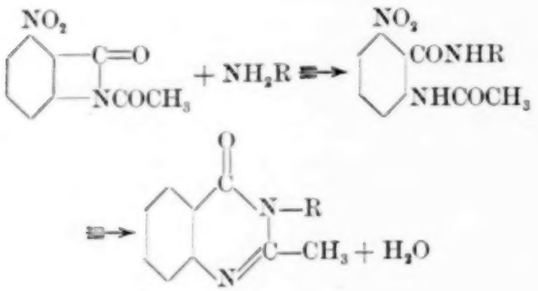


The well-known quinazoline syntheses when applied to *p*-diaminoterephthalic acid, in which the anthanilic acid grouping is present on both sides of the nucleus, should give such a compound. But diaminoterephthalic acid proved to be very inert, and no condensations could be made with it. It was found, however, that succinylosuccinic ester and guanidine condensed to a derivative of the above naphttetrazine. The method of preparation and subsequent analyses showed the product to be 2, 6-diimino- 4, 8-dioxy-hexahydro- 1, 3, 5, 7-naphttetrazine. There is a possibility also that the compound exists in the tantomeric form, having two amino instead of imino groups. The substance is soluble

only in caustic alkalies and strong mineral acids. From sodium hydrate it crystallizes as a di-sodium salt in beautiful yellow needles with green fluorescence. On the other hand, a sulphuric acid salt can be obtained in colorless rhombohedra by diluting the sulphuric acid solution with water.

Synthesis of Quinazolines from 6 Nitro-acet-anthranil: H. A. Seil and M. T. Bogert.

The 6 nitro-acet-anthranil was prepared by the action of acetic anhydride on acetanthranilic acid. It is much more reactive than the acetanthranil. It combines at once with primary amines forming first, the acid amide by direct addition, and then by loss of water passing over to the quinazolines.



The 6 nitro-acetanthranil is treated with an excess of the amine in a water solution of 1 to 3. It is brought to boiling and the excess of amine is distilled off. The solution is then made acid with acetic acid and filtered. The quinazoline thus obtained is purified by crystallization from alcohol.

The derivatives prepared are the methyl, ethyl, normal propyl, iso propyl, secondary butyl, iso butyl, iso amyl and allyl substitutions of the (2)methyl (5)nitro- (4)ketodihydroquinazoline. These are all white crystalline solids of high melting points; soluble in hot alcohol, slightly soluble in cold; soluble in dilute acetic acid (from which they can not be crystallized) and practically insoluble in water.

Influence of Organic Acids on the Precipitation of Antimony Sulphide: A. H. Peterson.

In the presence of a slight excess of mineral acids, relatively large quantities of certain organic acids prevent the complete precipitation of antimony sulphide by sulphuretted hydrogen. The influence was studied quantitatively and it was found that the influence was not directly proportionate to the masses of acid present, a limit being reached in each case, although the ratio of acid to the antimony present was inordinately large. The maximum effect obtained was for citric acid, which retains, in solution, seventy per cent. of the antimony present.

Of the acids studied, ethyl tartaric came next, then malic, while tartaric was the least energetic. The effect seemed confined to the oxy-acids, because succinic acid is without any effect and the influence of the citric acid is entirely lost when its hydroxyl group has been acetylated.

The Crystallization of Sodium Iodide from Alcohols: Morris Loeb.

It was accidentally observed that sodium iodide is extremely soluble in methyl alcohol and was not precipitated, even on the addition of considerable volumes of anhydrous ethyl ether. The alcohol solution, on cooling to room temperature, separates out crystals in long shining plates. Below 0° a voluminous mass of fine needles separates out, which are identical in composition, but different in appearance from those just mentioned. Melting point, 22 to 23°. Formula, $NaI.3CH_4O$. Under similar circumstances, ethyl alcohol dissolves the salt and crystallizes with it in proportion, $NaI.C_2H_6O$, while propyl alcohol yields $5NaI.3C_3H_8O$.

F. H. Pough,
Secretary.

The Torrey Botanical Club.

A meeting of the club was held at the museum of the New York Botanical Garden on Wednesday afternoon, April 26, 1905, with seventeen persons present and President Rusby in the chair.

The announced paper by Dr. P. A. Rydberg on 'The Composition of the Rocky Mountain Flora' was omitted by reason of the absence of the author.

'Notes on the Wire-Grass Country of Georgia' was the title of the paper presented by Mr. R. M. Harper.

The wire-grass country takes its name from the wire-grass, *Aristida stricta*, which is common all over it. In a broad sense, the wire-grass country coincides with the pine-barrens, which constitute about two-thirds of the coastal plain of Georgia, but for the present purposes the term is restricted to the Altamaha Grit region, an area of about 11,000 square miles.

The climate of the region, as compared with New York City, is about 18° warmer in winter and 9° warmer in summer. The rainfall averages about fifty inches a year, and most of it falls in the growing season. The geographical conditions are remarkably uniform throughout, and on account of this uniformity the flora is not very rich, only about one half as many species being known there as in the state of New Jersey, though the area is larger.

The region is naturally forested throughout, but the forests are mainly of long-leaf pine, which gives little shade. Consequently, the most striking feature of the vegetation as a whole is the adaptation to sunlight, usually manifested by reduction of leaf-surface.

The plants of the wire-grass country can be classified according to habitat into fifteen or twenty groups. The principal habitats are rock outcrops (constituting perhaps about one one-hundredth of one per cent. of the area), pine-barrens (over half the area), swamps, ponds, sand-hills, hummocks and bluffs, some of these with several subdivisions.

Civilization has influenced the flora principally through agriculture, lumbering, turpentining and fires. Only a small proportion of the land may be said to be under cultivation. Lumbering has little effect on the herbaceous flora, for the removal of the pine trees does not appreciably diminish the amount of shade. The turpentine operators have been practically all over that part of the country, and have done great damage to the forests. Fires sweep over most of the region every spring, being set purposely by stock-raisers to burn off the dead grass, but the fires do little damage where lumbering and turpentining operations have not been carried on.

The known flora of the Altamaha Grit region consists of about 725 native species of flowering plants, 75 weeds, 20 pteridophytes and 60 bryophytes and thallophytes. The lower cryptogams have been little studied. The largest families are Compositæ, 100 species; Cyperaceæ, 83; Gramineæ, 68; Leguminosæ, 50; Scrophulariaceæ, 30.

Some of the commonest species of the region are *Pinus palustris, P. Elliottii, P. serotina, Taxodium imbricarium, Aristida stricta, Serenoa serrulata, Eriocaulon decangulare, Quercus Catesbaei, Eriogonum tomentosum, Magnolia Virginiana, Sarracenia flava, S. minor, Kuhnistera pinnata, Cliftonia monophylla, Nyssa biflora, N. Ogeche, Oxypolis filiformis* and *Pinckneya pubens.*

The following species are common in the wire-grass country (each being known from at least three counties), but are seemingly confined to Georgia: *Sporobolus* (a species with terete leaves), *Rhynchospora solitaria* Harper, *Eriocaulon lineare* Small, *Polygonella Croomii* Chapm., *Siphonychia pauciflora* Small, *Viola denticulosa* Pollard (with leaves a foot and a half long), *Dicerandra odoratissima* Harper, *Pentstemon dissectus* Ell., *Baldwinia atropurpurea* Harper, *Marshallia ramosa* Beadle & Boynton and *Mesadenia* sp. (near *lanceolata*).

One of the most interesting features of the pine-barren flora, not generally known to botanists, is that the whole region was submerged beneath the sea in Pleistocene times, consequently the species now confined to the pine-barrens (from New Jersey to Texas), perhaps several hundred in number, have probably originated since that time.

Mr. Harper's remarks were illustrated by many photographs and specimens. The paper was discussed by Drs. Britton and Rusby.

Mrs. Britton then spoke of certain interesting southern mosses, especially of *Erpodium*, a curious genus having the habit of a *Frullania* or *Lejeunea*. A species of this collected many years ago by Sullivant at Augusta, Ga., was published by Austin as a hepatic under the name *Lejeunea biseriata*. Mrs. Britton discussed and exhibited also numerous mosses from the extreme southern part of Florida.

A few of these appear to be undescribed, but most of them are of species that are widely distributed in the West Indian region.

Dr. Rusby showed specimens of spurious ipecac roots which have found their way into the markets. The true ipecac (from *Cephaëlis Ipecacuanha* of the family Rubiaceæ) is now hard to obtain and high-priced. Some of the spurious root comes from other species of the same genus, but the most common adulterant is from the genus *Ionidium* (*Calceolaria*) of the family Violaceæ. Dr. Rusby exhibited also specimens of *Porteranthus stipulatus,* which is sometimes called the North American ipecac.

Dr. Britton showed living plants of two species of Crassulaceæ which had come into flower in the greenhouses of the New York Botanical Garden. One was *Sedum Nevii,* hitherto described from dried material, a species collected originally in southwestern Virginia, but since found to extend to Indiana. The other was a *Pachyphytum* from Mexico. Dr. Britton stated that in North America, north of the Isthmus, 284 species of Crassulaceæ may be recognized, distributed in 25 genera. Representatives of all these genera have now been studied in the living state.

Marshall A. Howe,
Secretary pro tem.

DISCUSSION AND CORRESPONDENCE.

THE METRIC ERROR.

To the Editor of Science: In your issue of March 24, Mr. Henry B. Hedrick, of the United States Naval Observatory, Washington, D. C., shifts from one metric fallacy to another. The regulation school children fallacy, as illustrated by the Hon. James H. Southard, chairman of the Committee on Coinage, Weights and Measures, in his report to the House of Representatives in 1902, and by Lord Belhaven in discussing a compulsory metric bill in the House of Lords on February 23, 1904, is that the adoption of the metric system will shorten the school life of every child, including all branches of study, from two thirds to three years; in other words, that the eight years will be cut down to seven and one third or even to five years. It is on this basis that Mr. Southard estimates a saving of $1,000,000,000 in every generation. It is clearly impossible to save by the adoption of the decimal system any of the time occupied by the study of non-mathematical branches, such as physical training, penmanship, languages, geography, history, nature study, drawing, cooking, sewing or music. The saving must be made in the time devoted to the study of compound numbers, weights and measures, which occupy 20 per cent. of the school arithmetic. Applying this rate, 20 per cent., to the 34⅓ weeks occupied during the eight years by all branches of mathematics, we find 6.8 weeks to be so consumed. This estimate is not only fair, but extremely liberal to the metric system. It is based on the eight-year schedule adopted for the public schools of New York City. The weekly time of 1,500 minutes is apportioned among the different branches, and the uncertain amount of time devoted to study outside of school hours is not included. Thus there is no confusion of schedule weeks with regular weeks. The case is simple. This metric fallacy is the claim that from two thirds to three years of the entire school life can be saved by the adoption of the metric system of weights and measures; when in fact, less than seven weeks is now devoted to compound numbers, weights and measures.

Turning from this old fallacy, let us consider the new one formulated by Mr. Hedrick to the effect that the adoption of the metric system would save ten per cent. of the time devoted to mathematics, or about two thirds of what may be called a mathematical year of school life. In other words, that 'the pupil would be about a year ahead in mathematics at the end of the eight years if he had only the decimal system to learn.'

In exposing this new fallacy it is unnecessary to dwell on the fact that the study of weights and measures in the school is merely very superficial memorizing and that the real knowledge of weights and measures is acquired outside of the school by using them; nor on the fact that the 34⅓ weeks covers

geometry and algebra, from which the special study of weights and measures is excluded. We can ignore these considerations because the fallacy of Mr. Hedrick's claim is due chiefly to his assumption that the use and study of fractions can be restricted to decimals. That is impossible because the universe is not built that way. To save time by abolishing the study of vulgar fractions is to promote ignorance, not knowledge. Such a policy of saving, carried to its legitimate conclusion, would do away with all study and award diplomas for what the graduate from the school of ignorance does not know.

The earth, from which the French scientists a century ago thought they had derived the meter, persists in revolving on its axis $365\frac{209}{864}\frac{26}{00}$ times during one revolution around the sun. Everything from the chemical combinations of the elements to the arrangement of the planets and fixed stars proclaims the eternal verity which John Quincy Adams thus expressed to Congress in 1821:

> Decimal arithmetic is a contrivance of man for computing numbers, and not a property of time, space, or matter. Nature has no partialities for the number ten, and the attempt to shackle her freedom with them will forever prove abortive.

It seems like a waste of time to demonstrate this self-evident proposition, but as many, including the House of Lords and the chairman of the Committee on Coinage, Weights and Measures of the House of Representatives, have reached the opposite conclusion, it may be worth while to ask them to examine a French arithmetic. Take that excellent work by Joseph Garnier, 'Traité complet d'arithmétrique théorique et appliqueé au commerce, a la banque, aux finance et a l'industrie.' The fifth edition (1900) contains not merely a few incidental references, but many comprehensive chapters dealing with vulgar fractions. Here are a few chapter headings: 'Numeration et propriétés des fractions ordinaires,' 'Reduction des fractions au même denominateur,' 'Simplification des fractions ordinaires,' 'Conversion d'un numbre entier, et d'une expression fractionnaire,' 'Addition des fractions ordinaires,' 'Soustraction des fractions ordinaires,' 'Multiplication des fractions ordinaires,' 'Division des fractions ordinaires,' 'Conversion des fractions ordinaires en fractions décimales et réciproquement,' 'Fractions décimales periodiques,' 'Question sur les partages proportionnels, sur les mélanges.'

If these titles are not sufficient the metric advocate in English-speaking countries can be convinced by reading the French arithmetic and studying its problems. It includes 43 pages on the metric system; 12 pages on old pre-revolutionary weights and measures; 13 pages on the comparison of the old measures with the new; 22 pages on compound numbers; and 36 pages on vulgar fractions.

The chapter on the metric system, entitled: 'Poids et Mesures—Nouvelles Mesures au Système Métrique,' effectually dispels the illusion that the metric system in its entirety is simple. The system is explained there, not to make converts to the metric cause, but for practical application to every-day work. The metric system in the French arithmetic with its foreign nomenclature and combination of decimal with binary divisions, such as *hectolitre, demi-hectolitre, double decalitre, decalitre, demi-decalitre, double-litre, litre, demi-litre, double decilitre, decilitre, demi-decilitre, double centilitre and centilitre,* is the very uniformity of confusion. There are the same complex vulgar fractions and weird problems that one finds in all school arithmetics, only in the French form perhaps a little more weird. And all this in France more than a hundred years after the following decree was issued by Robespierre:

> Decree of August 1, 1793.
>
> Art. 1. The new system of weights and measures founded on the measurement of the earth's meridian and the decimal division will be used throughout the Republic.

In the face of such evidence, what is left of the claim that the metric system will save two thirds of a year or two thirds of a minute in the study of mathematics in school?

That the teaching of the metric system in American schools at the present time is but a pretense can be proved by asking any graduate a few simple questions. The fact is, that the introduction of the metric system into English-speaking countries, instead of making

the education of the child easier, will make it vastly more difficult, because it will then be necessary to teach the old system, which will persist in use, and also to teach in fact as well as in name the metric system with the confusing ratios, direct and reciprocal, between the English and metric units.

If any one wants proof of this he can find it in the same French arithmetic. One chapter, 'Nomenclature des anciennes mesures et comparison avec les nouvelles,' treats of old units, a few of which are: *toise, pouce, ligne, aune, pas, lieue, perche, arpent, solive, corde, setier, muid, mine, minot, livre, once, denier, grain.*

If he still doubts let him go to some great French industry, textile manufacturing for example, and there study the chaos of weights and measures, thus described in 1902 by Paul Lamoitier, a French manufacturer:

> We are as much in the anarchy of weights and measures for the textile industry as at the time of the Revolution. * * *
>
> The famous aune, do you know its equivalent? Exactly 3 feet, 7 inches, 10 lines, and 10 points, or in other words, 1.188447 meters; the foot being equal to .324839 meter and divided into 12 inches, the inch into 12 lines and the line into 12 points.
>
> You would not imagine this as you are in the habit of calling it 1.19 meters. You laugh! It is, however, no laughing matter, unless you consider it as I do, profoundly ridiculous. * * *
>
> I will take my oath that the manufacturer of Rouen if he has not studied each section separately, has no idea what is the standard of Reims or the denier of Lyons or Milan. And on the other hand the manufacturers of Reims and Lyons are likewise puzzled in making comparisons of the diverse numberings of the diverse materials.

Such is the condition of French weights and measures at the present time. The evidence here presented is from French sources and makes ridiculous not only the claim of saving in education, but the whole metric proposition as well. This school children fallacy is confined to English-speaking countries where in the absence of experience with the metric system the imagination supplies the foundation for argument. The French labor under no such delusion.

Of course, if they insist, English-speaking countries can learn about the metric system in the high priced school of their own experience, but more than a century of experience in France can be had without money and without price.

Samuel S. Dale.

Boston, Mass.,
March 27, 1905.

Will the Metric System Save Time in Education?

In the article entitled, 'The Metric Fallacy,' Science, March 3, p. 353, is the statement that, in the New York public schools: 'The time allotted for all branches of mathematics amounts to $34\frac{1}{8}$ weeks for the eight years.' These figures relate to the actual time spent in recitation, which extends through nearly one year of school life, that is, about one eighth of the entire time. A complete education, to which Lord Kelvin referred in the British Parliament, includes high school and college, eight years more, which, with the same division of time, gives two years of solid mathematics. In England, one sixth, instead of one eighth is given to mathematics, and it is not extravagant to say that one half of this is wasted because of our barbarous weights and measures. Part of the economy of time shown in this country is due to our decimal money, part to the disuse here of many of the old English measures still taught in the English schools, and part to the greater use here of the metric system in our higher education, or perhaps it would be more correct to say, the non use therein of the English system.

Wm. H. Seaman.

Special Articles.

The Pelé Obelisk Once More.*

The recent massive-solid extrusion from within the crater of Mont Pelé has been de-

* Descriptions of the 'dome' and of 'spine' or 'obelisk' of Mont Pelé, with references to many previous papers relating to the volcano, may be found in: Hovey, E. O., 'The New Cone of Mont Pelé and the Gorge of Rivière Blanche,' in *American Journal of Science*, Vol. XVI., 1903, pp. 269–281. Hovey, E. O., 'The 1902–1903 Eruptions of Mont Pelé, Martinique, and the Soufrière, St. Vincent,' in *Comptes Rendus IX. Congrès géologique international*, de Vienne, 1903, pp. 707–738.

scribed by several observers as consisting of two parts: a 'dome,' and a 'spine' or 'obelisk.' The former was a dome-shaped elevation developed within the crater, which occupied a large portion and in fact nearly the whole of its interior and overtopped its rim. It was situated directly over the volcano's conduit, and numerous explosions occurred in its summit portion. The latter, *i. e.*, the 'obelisk,' was situated on one side of the dome and rose as a mighty tower to a height of more than a thousand feet above it. While the two structures just referred to have been described as distinct, perhaps in part for convenience in recording observations, there seem to be good reasons, as will be stated below, for considering them as parts of the same massive-solid extrusion or, as termed by some writers, 'cumulo eruption.'

In explanation of the upheaval of a mighty spire or obelisk of rigid rock from within the crater of Mont Pelé, two hypotheses have been offered. The obelisk has been considered by several geologists as the freshly congealed and rigid summit portion of a column of molten rock or magma, which was forced out of its conduit in a massive-solid condition. A second hypothesis, advocated by Angelo Heilprin,* is in brief, that a plug of old lava, formed by the cooling and hardening of a residuum left in the conduit of the volcano after some previous eruption, was forced upward and in part extruded from the crater.

Of these two hypotheses the known facts seem to favor the acceptance of the first mentioned, for the reason, in part, that the decidedly vigorous eruptions of the volcano, especially during the earlier stages of its present period of activity, when vast quantities of fragmental material were ejected, show that the conduit had what may be designated as a free vent. The large size of the column of black, debris-laden steam, estimated at 1,500 feet in diameter at the base, which at times rose straight into the air for several thousand feet, is also proof that the conduit was not seriously restricted in its upper portion, and demonstrates that one large opening and not several small orifices was present. The great amount of dense and seemingly old lava mingled with scoriaceous and fresher appearing material which has been discharged, is apparently good evidence that the plug of old lava present in the conduit when the recent eruption began, was, in part at least, shattered and the fragments, together perhaps with masses of similar material torn from the walls of the conduit, widely distributed as ejected blocks, lapilli, dust, etc. There are still other considerations which favor the idea that the obelisk was formed by the recent congealing of a rising magma, rather than that it was a solid mass at the beginning of the recent period of activity. Among these considerations is the fact that the total vertical measure of the massive-solid extrusion, in case the obelisk had not in part fallen from time to time, would have been some five or six thousand feet. The frictional resistance of such a plug, if rigid throughout, would, as it seems, have been greater than even volcanic energy could have overcome, and certainly far greater than is demanded by the hypothesis that a magma was cooled and consolidated in its upper portion as it rose from below. Then, too, as observation seems to indicate, Mont Pelé is composed principally of fragmental material ejected during previous eruptions, and the walls of the present conduit may reasonably be assumed to be relatively weak, and in case it had contained a solid 'volcanic neck' to a depth of five thousand or more feet, the fresh discharges would have found an exit by means of a new or side opening instead of pushing the plug out vertically and causing explosions about its periphery.

Recorded knowledge concerning volcanoes is still too incomplete to enable one to form a well-substantiated judgment as to the manner in which the reopening of a conduit is accomplished after a period of quiescence and apparent extinction, but the best tentative view in this connection seems to be that a magma in a volcanic conduit requires a long period of time, possibly several thousand years, to lose sufficient heat to admit of a change to a solid

* Heilprin, Angelo, 'The Tower of Pelée,' published by J. B. Lippincott Co., Philadelphia and London, 1904, size 9 by 12 inches, pp. 1–62 and 22 plates.

condition to a considerable depth. When pressure is renewed at the base or basal portion of a conduit after a period of rest, presumably the still hot material contained in it would afford the path of least resistance for the ascent of material forced upward from deep within the earth, and the former avenue of discharge would be reopened. As will be shown later, there are reasons for assuming that the magma in the conduit of a dormant volcano solidifies progressively from its periphery towards its center, and that previous to complete consolidation there is a tube of rigid lava present, enclosing a vertical core of plastic or liquid rock. The summit portion of the material in the conduit of a dormant volcano, however, is always rigid and must be fractured and the fragments produced ejected, or else heat ascending from a depth, perhaps conveyed by gases and vapors, leads to a sufficient increase in temperature to cause the previously solid lava forming the summit of the plug to become partially or wholly viscous. Should a condition of inactivity continue sufficiently long to permit the magma in a volcano's conduit to become solidified to a considerable depth, say several thousand feet, it is reasonable to assume that a truly extinct condition would be reached and that an increase of pressure at a depth would lead to the formation of fissures and the opening of a new conduit.

The speculations just indulged in seem to favor the hypothesis that the obelisk of Pelé was composed of fresh lava in distinction from lava formed by the secular cooling of a magma left in the conduit at the close of some former eruption. On the other hand, the change of a fresh magma, rising from a depth, to a solid condition as it nears the summit of its conduit, implies a very rapid rate of change from a plastic to a rigid condition. In this connection it is to be remembered that during a certain period of eighteen days the growth of the obelisk of Pelé was at the rate of about forty-one feet per day. The suggestion here presents itself that the rate of downward progressing change from a plastic to a rigid condition might not have been the same as the rate of bodily ascent. Most probably each process was variable. The portion of the obelisk extruded during a certain period of time may have required a longer period of time for its consolidation.

Under the assumption that the obelisk of Pelé was composed of fresh lava, two chief methods or processes have been suggested by which a change from a plastic to a rigid condition of the material extruded was brought about. One of these explanations and the one I have previously favored, ascribes the loss of heat from the magma in the summit portion of a volcano's conduit, mainly to conduction through its confining walls, aided, and perhaps dominated by, the cooling influence of descending percolating water. Assuming that this is the main process involved or the one as may be said in control, it follows that the magma adjacent to the walls of the conduit in its upper portion would change to a solid condition previous to the central part; that is, in a given horizontal section consolidation would progress from the circumference toward the center. Coupled with this process and as it seems an accompaniment of any method of cooling after the protrusion of solid material has begun, is the loss of heat from the exposed summit-portion of the column by radiation, escape of steam and gases through fissures, the cooling influences of rain, etc.

Another process by which the cooling of a magma in the summit-portion of a volcano's conduit may be brought about, has recently been suggested by A. C. Lane* and G. K. Gilbert,† and is based on the principle that vapors and gases on expanding withdraw energy from surrounding media, the assumption being that a rising magma near the condition of consolidation and containing occluded vapors and gases, would experience a decrease of pressure as it rose; and in consequence the vapors and gases would expand and withdraw heat from the walls of the containing vesicles and promote their solidification. The application of this principle to rising magmas seems to be legitimate, but implies that material is removed from the summit of the ascending column; if the material dis-

* Science, December 11, 1903.

† Science, June 17, 1904.

charged is all in a massive-solid condition, as, for example, in case a solid plug is forced out of a volcano's conduit, there would be no loss of pressure so long as the plug or obelisk remained intact—except the probably negligible part due to decrease in atmospheric pressure with increase of ascent above the summit of the conduit—and consequently, no tendency to upward expansion. As the extruded material emerged from its conduit, however, there would be a conspicuous decrease in resistance to lateral expansion and the mass should enlarge laterally, and in consequence cool most rapidly by reason of the expansion of occluded steam and gases, in its peripheral portion. That is, there would be a tendency for the extruded mass to expand horizontally on escaping from its conduit, and the energy so utilized would decrease the tendency to upward expansion. The higher the mass rose above the summit of its conduit the greater would be the pressure on its basal portion due to its increasing weight, and for this reason, also, there would be a tendency toward basal enlargement. By reason of these two processes, in case no loss was sustained owing to explosions, dislodgment, etc., there would be a tendency for the rising mass to assume a bottle shape, *i. e.*, a circular tower with an expanded base.

The two methods of cooling just considered have a joint tendency to cause the outer portion of the ascending mass to become rigid at an earlier stage than the central portion, and hence to form a hollow rigid tube enclosing a more highly heated and perhaps still plastic central core.

An inspection of the admirable photographs of the obelisk taken by E. O. Hovey, Angelo Heilprin and others, shows that it was situated sub-centrally in the crater from which it was extruded, and adjacent to its northeastern border. The side facing the center of the crater was rudely concave and its outer margin in horizontal section, somewhat definitely convex. The photographs also indicate that subordinate crags within the crater and in part adjacent to the base of the obelisk, were so arranged that in a horizontal section at the level of the crater's rim they, together with the base of the obelisk, formed a rude circle. These deductions, together with the fact that explosions occurred from time to time at the base of the obelisk and, as seems to have been the case, mainly on its southwestern or inner side, suggest that the tower-like mass was a portion of the encircling wall of an essentially hollow plug of rigid lava constituting the new dome, which was forced upward and out of the summit of the volcano. That is, the obelisk was a portion of the wall of a tubular plug, the greater portion of which became broken and was dislodged as it rose. The 'cork,' in other words, was not solid throughout in cross-section, but composed of a rigid enclosing wall, with less rigid and perhaps still plastic material in its central portion.

If the above deductions from the study of photographs and the observations of others are well founded, they certainly indicate that the cooling and consolidation of the magma in the conduit of the volcano progressed from its periphery toward the center. At the same time, whenever portions of the summit of the column were removed by explosions, or a portion of the obelisk fell—there having been no overflow of molten lava—decrease of pressure on the part remaining must have occurred, thus favoring consolidation throughout the summit-portion of the truncated column on account of the expansion of occluded steam and gases as outlined above.

It is suggestive to note also, as having a bearing on the general process of volcanic eruption, that relief of pressure brought about in the ways just considered, would favor a renewed ascent of the material remaining in a conduit, and likewise a renewal of explosions at its summit.

In the light of the hypothesis that peripheral cooling was the controlling condition in the case of the recent massive-solid eruption of Mont Pelé, several seemingly discordant observations may be grouped in orderly sequence. For example, the conical mound of rough, glowing lava present in the crater and resembling a 'cone of eruption' during the days immediately succeeding the great eruption of May 20, 1902, may be considered as

the congealed summit of a column of fresh lava which rose in the volcano's conduit. Beneath this hot and steaming initial plug, as may reasonably be assumed, the heat increased and the solid lava passed gradually into still plastic magma below. Cooling continued not only at the summit of the column as it rose on account of radiation, the escape of steam and gases from fissures, etc., and as has been suggested, on account of the expansion of steam and gases occluded in the magma, but also, and at a maximum rate, adjacent to the walls of the conduit principally through the influence of conduction and the ingress of surface water. The rise of the column, owing to pressure at its base, caused it to protrude from its encircling crater, but portions of its rigid wall fell or were shattered by steam explosions in its central part and only the remnants left standing reached a conspicuous height. The changes in the position of the obelisk as observed from time to time seem consistent with the explanation just offered, since the fall of one prominent spine or obelisk would leave some other portion of the rim conspicuous, and as it in turn was forced upward, seem to take the place of its fallen predecessor.

The fact that the outer surface of the obelisk, *i. e.*, its northeastern side, was striated vertically, owing to friction against the wall of the conduit from which it was protruded, is evidence that there was but little if any opportunity for steam to escape from below in that portion of the periphery of the crater. If the rising plug fitted its conduit equally well all about its contact with its enclosing conduit, it is difficult to understand where the numerous steam explosions which are known to have occurred adjacent to the base of the obelisk, were located—in case the plug was solid throughout its summit-portion. On the other hand, if it is assumed that the inner part of the rising column was less rigid than its outer portion, and as is consistent with this idea, perhaps even plastic at the center, it is legitimate to infer that the central portion of the summit of the rising column was removed by steam explosion, at the same time that the more prominent crags on the crest of its rigid peripheral portion were caused to rise high in the air.

Another series of facts which demands consideration in the above connection is that the rate of ascent of the dome and of the obelisk was not the same. Explosions occurring in the summit of the dome removed portions of its mass and a similar result was brought about in the case of the obelisk by the dislodgment of fragments. Varying conditions were thus introduced, but so far as can be judged the rate of ascent in either instance did not respond to these changes. Why the energy exerted in causing the massive-solid extrusion was not all consumed in elevating the core of the plug, where the resistance from weight was the least, and where the temperature was highest and consequently the tendency to plasticity the greatest, is far from clear. This is one of the considerations which advocates of the 'fresh lava hypothesis' to account for the production of the Pelé obelisk are called upon to meet. But in this connection, as in reference to the rapid rate of cooling demanded by that hypothesis, an adequate explanation does not seem to be at hand.

Sequence of Events.—The sequence of events during a massive-solid volcanic eruption, and the leading variations in what may be termed the normal process due to secondary conditions, may provisionally be grouped as follows:

If the magma forced upward from deep within the earth, through a volcano's conduit, becomes highly viscous or nearly solid before reaching the surface, it may be forced out of the conduit and expand in the crater to which the conduit leads. The amount of expansion will depend principally on the degree of plasticity of the mass, the range being from such a degree that the material will flow under the influence of gravity, to rigidity under the pressure present. The distinction between an effusive and a massive discharge is that the material extruded in the former instance is sufficiently mobile to flow and possibly to form a well-defined stream, and in the latter instance is so viscous or even rigid that lateral motion does not result. Between the two there

is a complete gradation. The range in the physical condition of the extruded lava is from fluidity approaching that of water, to rigidity such as cold lavas ordinarily present.

The constructional shapes resulting from the extrusion of lava ranging in consistency from a highly viscous to a rigid condition, should form a sequence from irregular tumefactions and bottle-shaped towers, to angular crags with nearly vertical sides. A sequence of variations should also be produced owing to the amount of material extruded, its rate of ascent, etc. The constructional topographic forms should present destructional modifications, in case explosions occur, or portions of the extruded material are dislodged.

The results produced by massive-solid eruptions, as may be judged if all the modifying conditions are considered, are so varied that it is not practicable at present to follow each modification in detail. The place of the Pelé obelisk in the general sequence, however, may be readily indicated.

Under the hypothesis that the Pelé obelisk was composed of fresh lava, which congealed and became rigid, at least in part, as it rose through its conduit, and was protruded high in the air, let the reader endeavor to construct in fancy the topographic form that would have resulted, had there been no explosions and no loss owing to dislodgment. Under these assumptions the outer portion of the extruded mass would cool more rapidly than its central portion, and the surface might become rigid while the core was yet plastic.

FIG. 1. Ideal diagrams illustrating the shapes of massive-solid volcanic extrusions.

The extruded material at an assumed stage in the eruption would have some such form as is outlined in Fig. 1, *a*. At such a stage the highly heated core of the extruded column might serve as a continuation of the conduit and an escape of steam possibly with explosive violence and accompanied by fragmental discharges, occur in the pseudo-crater at its summit.

Providing explosions occurred as the dome rose, it might be more or less shattered. Vigorous explosions might remove the summit-portion of the ascending mass as fast as it was forced out of its conduit, and the fact that a massive-solid extrusion had occurred be masked so as to make it appear that only a fragmental-solid eruption was in progress or had taken place. It should be borne in mind that effusive, fragmental-solid and massive-solid eruptions with all of their varied accompaniments are but phases of a single process.

Vigorous explosions during the ascent of a column similar to the one suggested in Fig. 1, *a*, might cause the removal of a part of the material composing it, leaving portions of its solid exterior standing as angular crags and tower-like spines as shown in Fig. 1, *b*. This diagram, as the reader will recognize, is intended to indicate in outline—all suggestions as to accumulation of débris, and other secondary results being eliminated—the condition of the massive extrusion in the crater of Mont Pelé at the time the obelisk was most prominent. During the continuance of the conditions indicated in the diagram, vigorous explosions might occur in the truncated summit of the 'dome' while portions of its shattered periphery formed conspicuous eminences. Explosions of this nature, as has been observed, occurred in the summit of the 'dome' of Mont Pelé; and, as it is reasonable to assume, the final fall of the obelisk was due chiefly to the shocks caused by explosions at its base. The general shape that the extruded material would present after being truncated by explosions, is roughly indicated by Fig. 1, *c*.

The considerations just presented seem to make it reasonable to conclude as already stated, that the 'dome' and the 'obelisk' of Mont Pelé were parts of the same massive protrusion and that the various shapes assumed from time to time were due mainly to the shattering and in part the dispersion of the rising mass by steam explosions; also,

that the material extruded in a massive condition consisted of fresh lava which was forced outward from deep within the earth. The observed results appear, also, to be consistent with the view that the cooling of the material extruded progressed most rapidly in its peripheral portion and that its central portion, particularly after partial truncation had occurred, was sufficiently hot to cause explosion accompanied by fragmental-solid discharges.* If these contentions are well founded, it follows that the exterior of the plug—considering the dome and the obelisk as portions of a single extruded mass—should be composed of dense and possibly vitreous rock, and become more and more scoriaceous towards its center.

The above suggestion in reference to the physical condition of the extruded material differs from the conclusion reached by me in the same connection, in a previous publication,† which was based largely on the observed granular condition of the rock present in the central portion of a massive-solid extrusion near Pauline Lake, Oregon.‡ This discrepancy seems to indicate that the conditions which modify massive-solid eruptions are more varied than is at present understood and that the results in any two instances may not be closely similar.

The theory of volcanic eruptions may instructively be pressed a step farther: As the cooling and consequent consolidation of a magma forced out of a conduit in a viscous or solid condition, progresses from its periphery towards its vertical axis, it follows that in case a volcano becomes dormant the same process will continue in the deeper portions of the conduit, and should eruptions be renewed after a period of rest, the avenues of discharge should be through the central part of the partially consolidated material in its throat. In case the energy of the renewed eruptions was not sufficient to fracture and discharge, or the heat adequate to re-fuse the consolidated lining of the conduit, it would remain, and if the process was repeated, the tube would become closed by successive additions to its rigid lining, and final extinction result.

In the case of Mont Pelé, the process just outlined is, perhaps, in progress, and the dense rocks in the rim of the crater, which form Morne Lacroix and Petit Bonhomme, be representatives of the outer portion of a previous eruption similar to the one of recent occurrence.

Generalizations.—The various forms which massive-solid volcanic eruptions may be expected to assume should be regulated by several secondary conditions, a number of which might be in operation during a single period of discharge, or some one dominate all the others. For example: (1) the physical condition of the extruded material may range from plasticity to rigidity, dependent upon the chemical composition of the rising magma, its temperature, rate of cooling, rate of ascent and probably still other conditions; (2) the degree of explosive energy may range from such intensity that the entire summit-portion of the extruded material would be blown away, to such feebleness that but little change would be produced in the constructional form due to extrusion; (3) differences in the rate of cooling and consequent consolidation may result in the formation of a solid plug, or a plug with a rigid exterior and a still plastic interior. Each of these various conditions would react on many, if not all, of the others, and in consequence the variations in the final result,

* The above considerations seem to be in harmony with the results reached by A. Lacroix, in a recently published volume ('La Montaigne Pelée et ses eruptions,' Paris, 1904). This report has not reached me, but a review by Ernest Howe, SCIENCE, April 14, 1905, contains the following statement: "Lacroix denies that it (the dome) is of fragmental nature and states that it is, in fact, a homogeneous mass of viscous lava surrounded by an envelope of the same substance cooled and consolidated. * * * The viscous magma on reaching the surface through the throat of the volcano and forming a protuberant mass is quickly surrounded by a solid shell or envelope which protects the still pasty interior from a too rapid cooling."

† Russell, Israel C., 'Criteria Relating to Massive-Solid Volcanic Eruption,' in *American Journal of Science*, Vol. XVII., 1904, p. 264.

‡ Mount Newberry, U. S. Geological Survey, Bulletin No. 252, 1905, pp. 97, 106–109.

whether considered geologically or topographically, have a wide range.

It is to be remembered, however, that massive-solid eruptions are but one phase of the volcanic problem and, for their complete elucidation, should not be rigidly separated from other phases of the same process.

ISRAEL C. RUSSELL.

RECENT VERTEBRATE PALEONTOLOGY.

FOSSIL MAMMALS OF MEXICO.

THE mammalian paleontology of Mexico offers a most interesting field for investigation, since it promises to reveal the southern range of many North American Miocene and Pliocene types, as well as the northern range of South American types, Pliocene and Pleistocene, in addition to many types which will be found to be peculiar to Mexico. The literature of the subject is still quite limited, including contributions by Richard Owen,* by Professor Cope† and a recent interesting memoir by Dr. M. M. Villada,‡ of the National Museum of Mexico.

In connection with the proposed visit of the International Geological Congress to Mexico in the summer of 1906 the following cursory notes may be of interest.

The elephant remains in the National Museum have usually been ascribed to *Elephas columbi;* but they include molar teeth not only of this species, but of the much larger form, *Elephas imperator.* In the collection of the Geological Survey of Mexico in the new survey building are the skull and tusks of an *E. imperator* of magnificent proportions, the tusks measuring 5 m. 10 cm., or 16 feet 10 inches, in length; this specimen was secured during the excavations for the great drainage canal of the Mexican Valley. Owen's type of *Equus conversidens* and *Equus tau* from the valley of Mexico belong to the National Museum, but are not at present accessible, owing to changes in the building. There is, however, the skull of a Pleistocene horse from the valley of Mexico referred by Villada to *E. excelsus,* but probably belonging to a distinct and much more massive type of animal with exceptionally powerful postorbital arches. Here also is found the fine carapace of a glyptodon (*Glyptodon mexicanus*).

The new building of the Geological Institute of Mexico is being pushed forward to completion with a view to the visit of the International Geological Congress. The director, Dr. José G. Aguilera, very kindly exhibited to us the chief specimens of mammalian fossils. These include the skull of a mastodon probably related to the South American *M. humboltii,* the palate and teeth of a small variety of horse of the size of a donkey, labeled by Castillo in 1866, but not yet described. Besides the skull above noted there are several single teeth of *Elephas imperator,* molars of the *M. humboltii* type from Chiapas, of the *E. columbi* type from the village of Zacapù in Michoacan, of *E. imperator* from the valley of Puebla. In a bed of lignites, probably of Upper Miocene or Loup Fork age, were found the types of *Hipparion* (=*Protohippus*) *castillei* Cope, and teeth belonging to *Mastodon floridianus,* also teeth of the peccary. Also probably of Loup Fork age from the valley of Toluca is the jaw of a rhinoceros, a very short-skulled type, the canines being separated by very short intervals from the premolars, while the molar teeth are exceptionally long-crowned. Very large horse teeth found in the

* Owen, R., 'On Fossil Remains of Equines from Central and South America referable to *Equus conversidens* Ow., *Equus tau* Ow., and *Equus arcidens* Ow.,' *Phil. Trans.,* 1869, pp. 559–573. 'On Remains of a Large Extinct Lama (*Palauchenia magna* Ow.) from Quaternary Deposits in the Valley of Mexico,' *Phil. Trans.,* 1869, pp. 65–77.

† Cope, E. D., 'Review of Dumeril et Bocourt's Mission Scient. Mexique,' *Amer. Nat.,* Vol. XVIII., 1884, p. 162. 'Gigantic Bird from Eocene of Mexico, *Diatryana Gigantea,*' *Pr. A. N. S.,* 1876, p. 10. 'Extinct Mammalia of the Valley of Mexico,' *Proc. Am. Philos. Soc.,* Vol. XII., 1884, 117, p. 1. 'Report on Coal Deposit near Zacualtipan, Hildalgo, Mexico,' *Proc. A. P. S.,* XXIII., 122, 1885, p. 1. 'The Comision Cientifica of Mexico,' *Amer. Nat.,* XIX., 1885, p. 494.

‡ Villada, Manuel M., 'Apuntes acerca de la fauna fosil del Valle de Mexico,' *Anales del Museo Nacional de Mexico,* T. VII., Entrega 14, Ma, 1903, pp. 441–451, 8 pll.

valley of Mexico may correspond with the large skull in the National Museum. Of great interest is the skull of a very large true cat, puma-like, found in the excavations of the Grand Canal.

From the Pleistocene near Zumbango, state of Mexico, remains of a large undescribed bear have been found. Here also is the type of *Glyptodon mexicanus*. A complete shield of the same animal is reported to be in the collection of the school of mines. In the same collection is found a fine specimen of *Bison latifrons* and remains of fossil horses.

The gravigrade sloths are represented by teeth from Tequixquiac.

From the state of Chihuahua, northern Mexico, are remains of Upper Pliocene or Pleistocene horses and llamas. Fossils are, however, most abundant in the Lower Pleistocene of Puebla near the city of Puebla in the village of Totemehuacan. A fine collection from this locality was lost by fire while on its way to the United States for study. An older horizon is also represented here. The mastodons were very widely distributed, teeth coming from Hidalgo, from the valley of Toluca, from Teul in the state of Zacatecas. Abundant elephant teeth are also reported by Mr. C. W. Beebe from the Lower Pleistocene, near Guadalajara.

In 1903 the Mexican government made provision for the increase of the staff of the Geological Institute which had been created by congress in 1888. The staff now includes the director, Dr. José G. Aguilera, an assistant director, six geologists, three assistant geologists, one chemist and assistant, three topographers. The director is now giving his most active attention not only to the actual field work of the survey, but to the extension of the library and to the arrangement of the collections, in preparation for the visit of the International Geological Congress.

H. F. O.

MUSEUM PUBLICATIONS.

The Annual Report of the Director of the Field Columbian Museum for 1903–1904 chronicles the steady growth of this great museum and emphasizes the necessity for having its collections transferred to permanent quarters as soon as possible.

This museum probably has the largest and best display of botanical material of any institution in the United States, and judging from the plates the specimens are very well exhibited. The collections illustrating mineralogy and economic geology are also large, well displayed and well labeled. But when it is stated that 500 labels were needed to *complete* the labeling of the gold and silver ores alone, it leads one to ask if there may not be such a thing as displaying too many specimens. We have all heard of the man who could not see the forest for the trees, and there is danger that the museum visitor may fail to grasp a few general and important facts on account of the number of details. The modern tendency of museums is to lessen the amount of material on exhibition and to increase its educational value, and there is no doubt that a small number of specimens well displayed and well labeled are more effective than a multitude of objects.

The list of Museum Publications is a strong one and the two volumes of Elliot's 'Land and Sea Mammals of Middle America and the West Indies' were most acceptable. Zoologists may not agree with Mr. Elliot in all his conclusions, but it remains to be said that no one but he has had the courage to attempt the task of bringing together and systematizing the present knowledge of the mammalian fauna of North America.

The Prize Essay Contest, published by the Carnegie Museum, forms a pamphlet of 68 pages, containing the addresses delivered on the occasion of awarding the prizes, with lists of the prize winners and contestants; although the essays themselves are not printed as has heretofore been the case.

Undoubtedly these contests do much to bring children to the museum, but it is a little questionable if they do not think more of the possibility of winning a prize than of the objects in the collections, and it would be interesting to know how many go again.

It is surely a good thing to induce the public to visit a museum, but might not the machinery of the Prize Essay Contest have

achieved even more permanent results if used in some other way?

In looking over the reports of various museums it becomes evident that too much stress must not be laid on mere number of visitors. Three great institutions show a drop in 1903 or 1904 of from 70,000 to 50,000, while the United States National Museum exhibits a large increase, following a large decrease. None of the museums in which the attendance has declined has fallen off in the quantity or quality of their displays; on the contrary, they have made very great progress, and yet the public for some unexplained reason seems temporarily to have lost interest. How much the frequent expositions of the last ten years may have had to do with this it is impossible to say, but it probably has had its effect in decreasing attendance.

F. A. L.

SCIENTIFIC NOTES AND NEWS.

PROFESSOR L. HERMANN, Königsberg, Professor H. A. Lorentz, Leyden; Professor Henri Moissan, Paris, and Professor Hugo de Vries, Amsterdam, have been elected foreign members of the Royal Society.

DR. FRIEDRICH KOHLRAUSCH, who recently resigned the directorship of the Reichsanstalt, and has changed his residence, has been made an honorary member of the Berlin Academy of Sciences instead of a resident member as hitherto.

M. LOUIS HENRY has been elected a corresponding member of the Paris Academy of Sciences, in the section of chemistry.

CAMBRIDGE UNIVERSITY has conferred the honorary degree of Sc.D. upon Commander R. F. Scott and Sir Francis E. Younghusband, K.C.I.E., LL.D.

THE Broca prize of the Paris Anthropological Society has been awarded to MM. Launois and Roy for their biological study of gigantism.

PROFESSOR GEORGE T. LADD, who has resigned from the chair of philosophy at Yale University, has arranged to pass the latter half of next year as professor of philosophy at Western Reserve University. At the close of the war in the east he expects to go to Japan to lecture on educational methods under the auspices of the Japanese Imperial Education Society.

DR. B. F. CLARKE, professor of mechanical engineering at Brown University, retires at the end of this year, in accordance with the pension regulations recently adopted by the corporation.

DR. G. F. HULL, Appleton professor of physics at Dartmouth College, will spend next year abroad, working in the laboratory of Professor J. J. Thomson, at Cambridge.

PROFESSOR OLIN F. TOWER, of Western Reserve University, has a six months' leave of absence, which he is spending at the University of Berlin.

DR. W. J. HUMPHREYS, Ph.D. (Johns Hopkins, '97) has been appointed chief physicist of the United States Weather Bureau, in charge of the new physical laboratory in the mountains of West Virginia, near Gap Mills. Before assuming his new duties, Dr. Humphreys will go abroad to study foreign laboratories.

MR. I. B. POLE EVANS, B.Sc. (Wales), has been appointed assistant for plant diseases under Mr. J. Burtt-Davy, government agrostologist and botanist of the Transvaal Department of Agriculture. Since October, 1903, Mr. Pole Evans has been working for his research degree at Cambridge under Professor Marshall Ward, being engaged principally in an investigation of the rusts of cereals. During this time he has been acting as demonstrator in elementary biology for Mr. Seward, and last term had charge of the practical work of Professor Marshall Ward's advanced course on fungi. The cereals of the Transvaal are greatly affected by parasitic fungi, and its flora presents a new and practically untouched field for the mycologist.

PROFESSOR BERNHARD PROSKAUER has been appointed head of the chemical department of the Institute for Infectious Diseases at Berlin.

THE courses that Professor Wilhelm Ostwald, of the University of Leipzig, will offer at Harvard University during the first half

of the approaching academic year are: 'The Philosophy of Natural Science,' three lectures a week, and 'The Fundamental Conceptions of Chemistry' and 'Catalysis,' each one hour a week.

Sir Francis Younghusband gave the Rede lecture at Cambridge University on June 10, his subject being 'Our True Relationship with India.'

For the purpose of scientifically exploring the atmosphere, Comte de Castillon de Saint-Victor made an ascent on June 7, in his balloon *Centaure,* taking with him M. Joseph Jaubert, director of the municipal observatories of Paris, and Dr. Jolly. Other aerostatic ascents were made on the same day from Berlin, Strasburg, Barman, Munich, Vienna, Zurich, Rome and Trappes.

The statue of Sir Thomas Browne, which is being executed by Mr. Henry Pegram, A.R.A., is now well advanced, and it is intended that it shall be erected and unveiled in its position in the Haymarket, Norwich, on October 19, the tercentenary of Sir Thomas Browne's birth.

The class of 1904 of the University of Pennsylvania is collecting funds to erect a statue of Benjamin Franklin, the founder of the university. The class of 1905 has voted to erect a statue of William Smith, the first provost of the university.

Part of the old Speedwell iron works, near Morristown, N. J., in which Professor S. F. B. Morse and Stephen Vail perfected their first telegraph instrument, was destroyed by fire on May 22.

Dr. Ernst Küster, professor of surgery at the University of Marburg, will deliver the principal address at the unveiling of the memorial to von Esmarch, at Tönning, his birthplace, which will take place on August 6.

Dr. Albert Hilger, professor of applied chemistry at the University of Munich, died on May 18, at the age of sixty-six years.

There will be a civil service examination on July 5 for the position of aid in the Bureau of Plant Industry, Department of Agriculture, at a salary of $600 a year.

A collection of birds' eggs, consisting of complete sets, representing more than five hundred different species of birds, made by Mr. Gordon Plummer, has been presented to the biological department of Dartmouth College by his son.

Mr. J. Pierpont Morgan has presented to the American Museum of Natural History the George F. Kunz collection of meteorites, which has been on exhibition for some years as a loan. The collection comprises some rare specimens, including two which are unique and have never been described, and the largest mass (1,038 pounds) of Cañon Diablo which has been found. The department of conchology has received from Mr. F. A. Constable a gift of the last instalment of the celebrated Hirase collection of the land shells of Japan, and the series is now on its way to the museum. This instalment comprises about 1,000 specimens of shells belonging to 220 species, bringing the total of the Hirase collection in the possession of the museum up to about 4,000 specimens of 800 species. The series is fully representative of the land molluscan fauna of Japan, and while the specimens are not strikingly beautiful, they are of high scientific interest.

The sittings of the delegates appointed to consider the establishment of an International Agricultural Institute began at Rome on May 30. The London *Times* states that the conference has appointed three committees. The first, which will consider the organization of an international institute, has appointed as its chairman the French ambassador and as members the other ambassadors and some of the delegates to the conference, including Sir Thomas Elliott and Sir Edward Buck. The aims which the institute is to attain will form the subject of the second committee's attention. This committee will be divided into two sections, of one of which Lord Minto has been appointed president, while Sir Thomas Elliott is among the members. The task of the third committee is to examine the methods of defraying the expenses of the institute. Signor Rava, minister of agricul-

ture, will preside over it, and Lord Jersey and Mr. Gill will be among its members.

IT is announced that the *Proceedings of the Royal Society* is henceforth to be brought out in a new form. It will assume royal octavo size, and be printed in larger type than is the case at present. Also two series will appear in future, one embracing mathematical and physical papers, the other biological papers, and each part will be on sale to the public separately.

AT a meeting of the Zoological Society of London on April 18, Dr. W. J. Holland, F.Z.S., director of the Carnegie Museum and Institute, Pittsburg, U.S.A., gave an account, illustrated by stereopticon slides, of the discovery of the skeleton of *Diplodocus carnegii* Hatcher, a reproduction of which he was installing in the Gallery of Reptiles at the British Museum (Natural History), South Kensington. After paying tribute to the generosity of Mr. Andrew Carnegie, who had supplied the funds necessary for the extensive explorations which were being carried on by the Carnegie Institute, under the direction of the speaker, he went on to speak of the geology of Wyoming and of the immediate locality, where the specimen was obtained. He incidentally described the methods employed by American collectors to secure vertebrate fossils in fine condition. He then discussed the osteology of *Diplodocus*, briefly pointing out some of the more interesting structural features of the skeleton, and in this connection animadverted upon certain so-called 'restorations' made public in popular magazines and emanating from artists whose artistic ability was quite in excess of their scientific knowledge. Dr. Holland concluded his account by exhibiting in rapid succession pictures of a few of the more remarkable skeletons which had been recovered by the paleontological staff of the Carnegie Museum from various localities in the region of the Rocky Mountains. At the same meeting Dr. Smith Woodward, F.R.S., read a paper on a unique specimen of *Cetiosaurus leedsi*, a Sauropodous Dinosaur from the Oxford Clay of Peterborough. He described the fore and hind limbs and the tail, and confirmed the observation of the late Professor O. C. Marsh, that *Citiosaurus* was one of the more generalized Sauropoda.

MR. EDWIN C. ECKEL, of the United States Geological Survey has just completed a report on the cement materials and industry of the United States. In view of the phenomenally rapid growth of the cement industry within recent years, the publication of this report is exceptionally timely. In collecting data for it, Mr. Eckel visited every district in which cement is produced and examined nearly every plant in operation. Information relating to undeveloped deposits of cement materials was obtained by personal examination and from the published and unpublished work of other geologists. The discussion is in four parts, the first relating to the materials and manufacture of Portland cement, the second to Portland cement resources of the United States, the third to natural cement resources of the United States, and the fourth to the materials and manufacture of Puzzolan or slag cement. Few people realize how manifold are the uses of cement. In its importance to our present civilization it is surpassed among mineral products only by iron, coal and oil. In rate of increase in annual production during the last decade even these three products can not be compared with it. In 1890 the total production of Portland cement in the United States was 335,500 barrels, valued at $439,050; in 1903 it exceeded 22,000,000 barrels, while the value was over $27,000,000.

UNIVERSITY AND EDUCATIONAL NEWS.

THE proposed affiliation or alliance of the Massachusetts Institute of Technology with Harvard University was approved at a meeting of the corporation of the institute on June 9. Thirty-two of the forty-seven members of the corporation were present, and by a vote of 20 to 12 it was agreed to accept the terms of the agreement recently drawn up by the committee of the two institutions. Before the agreement can become effective the corporation and overseers of Harvard University must take action and several legal questions must be passed upon by the courts. It will

be remembered that on May 5 the faculty of the institute adopted by a vote of 56 to 7 the report of the committee adverse to the affiliation. A full account of the report adopted by the faculty and of the minority report, together with an account of the meeting of the alumni on May 4 has been published in a special issue of *The Technology Review*.

General William J. Palmer, of Colorado Springs, Col., and Mr. Andrew Carnegie have donated respectively $100,000 and $50,000 as a nucleus to the $500,000 endowment fund for Colorado College.

At the Commencement exercises of the Catholic University of America the rector, Mgr. O'Connell, stated that the university possesses, untouched by the Waggaman failure, assets and resources valued at $1,003,801. The bishops' collection ordered by the pope has resulted in $113,550 being turned into the treasury from 77 dioceses. A contingent fund of $200,000 has been raised since the Waggaman failure and has been invested in railroad bonds.

Earl B. Lovell, adjunct professor of civil engineering at Columbia University has been appointed director of the College of Civil Engineering, at Cornell University, as successor to the late Professor E. A. Fuertes.

Dr. Ralph Hamilton Curtiss, lately Carnegie assistant at the Lick Observatory, has been appointed assistant professor of astronomy at the University of Western Pennsylvania.

In accordance with the tutorial system adopted by Princeton University, preceptors with the grade of assistant professor have been appointed in the department of philosophy and psychology as follows: Professor R. B. Johnson, of Miami University; Dr. Adam Leroy Jones, of Columbia University; Professor W. T. Marvin, of Western Reserve University; Dr. Wilmon H. Sheldon, of Columbia University, and Dr. E. G. Spaulding, of the College of the City of New York.

The following appointments have been made in the scientific departments of the University of North Carolina: T. F. Hickerson, instructor in mathematics; J. C. Hines, Jr., assistant in physics; E. B. Jeffress and B. H. Perry, assistants in geology; W. H. Kibler, B. F. Royal, T. P. Cheshire, assistants in biology; E. E. Randolph, C. W. Martin, L. M. Kelly, G. L. Paddisson, assistants in chemistry.

Dr. James Bissell Pratt has been appointed instructor in philosophy and psychology, at Williams College.

Two fellowships of the value of $500 each, granted annually by the Woman's College of Baltimore, have this year been awarded to Miss Sabina Claire Ackerman, Easton, Pa., who will study chemistry at the University of Pennsylvania, and to Miss Sara White Cull, who will study biology at Columbia University. Other awards in science were as follows: The two scholarships at the Marine Biological Laboratory, at Woods Hole, Mass., to Miss Katie M. Brough, of Hanover, Pa., and to Miss Mary J. Hogue, of West Chester, Pa., both members of the graduating class. Three Woman's College scholarships, established at the Cold Spring Harbor Marine Laboratory of the Brooklyn Institute of Arts and Sciences, to Miss Ethel Nicholson Browne, Miss Hettie Cole Caldwell and Miss Maude Cecil Gunther, of Baltimore, members of the junior class.

Mr. Clarence Morgan (Harvard) has been appointed to the new chair of railway transportation at McGill University, and H. H. Mackay (Dalhousie) has been appointed assistant professor of civil engineering.

Mr. William Findlay, tutor in mathematics at Columbia University, has been appointed professor of mathematics at McMaster University, Canada.

Mr. A. R. Lord, B.A. Oxon., assistant to the professor of moral philosophy and lecturer on political science in Aberdeen University, has been appointed professor of philosophy and history in the Rhodes University College, Grahamstown, Cape Colony.

Mr. Edward P. Culverwell, M.A., fellow of Trinity College, Dublin, has been appointed to the new chair of education in the university.